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ABSTRACT

Investigating how good and poor readers process words, a study examined the spelling and reading processes of 80 middle-class first grade students from three schools in Houston, Texas, 40 who were receiving whole word instruction, and 40 receiving phonics instruction. Based on scores from the Gates-McGinitie Reading Test, Basic R (administered in October of the first grade year), subjects whose grade equivalency scores were greater than 1.3 were categorized as good readers, and those with scores equal to or less than 1.3 were categorized as poor readers. To determine whether words were processed visually or phonologically, students were given 60 single-syllable words--consisting of regular words, whose spelling conformed to grapheme-phoneme correspondence (GPC), and exception words, whose spelling did not conform to GPC--to read orally, spell, and recognize in lists of other words. After a week-long spelling test covering the words, students were administered the Peabody Picture Vocabulary Test, an oral reading test of the 60 words, a recognition reading test of the 60 words (with and without a clue condition), and Rosner's Test of Auditory Analysis Skills (TAAS). Results indicated that both good and of poor readers processed words differently depending on the nature of the task. Good readers were superior in phonological recoding and application of GPC rules and were weaker in utilization of visual-orthographic knowledge. Mid-year data collected in February and end-of-the-year data collected in May will also be analyzed. (Two tables of data are included.) (MM)

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Visual and Phonological Processing of Words: A Comparison of Good and Poor Readers

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Visual and Phonological Processing of Words: A Comparison of Good and Poor Readers

The assumptions guiding the present investigation are that (1) developmental dyslexics are more accurately described as very poor readers than disabled readers (See Bruck, 1988; Seidenberg, Bruck, Fornarolo, & Backman, 1986; Stanovich, 1985; Stanovich, Nathan, & Zolman, 1988) because (2) their skills in phonological and visual analysis of words fall at the low end of the same continuum of skills evidenced by normal readers (e.g., Bryant & Impey, 1986), with a developmental progression from visual, to visual and phonological, to visual-orthographic (e.g., Frith, 1985). Furthermore, it is assumed that (3) the method of beginning reading instruction (phonics versus whole word) mediates pre- and postlexical routes to word processing (e.g., Perfetti,. Beck, & Hughes, 1981 reported in Perfetti, 1985) and that (4) knowledge of a word's spelling is relevant to how a word is read (See Ehri, 1986 for a review).

Today we present results of the first phase of a year-long study of first grade reading and spelling. Eighty first graders, one-half of whom were receiving whole word instruction, half of whom were receiving phonics instruction were given 60 single-syllable words to read orally, to spell, and to recognize in lists of other words. To determine whether children processed these words visually or phonologically, both regular and exception words were included. The spelling of regular words conforms to grapheme-phoneme correspondence (GPC) rules while the spelling of exception words do not. Examples of regular words are cart

and rent; examples of exception words are comb and though. If a reader is primarily processing words phonologically, then recognition of regular words should be better than recognition of exception words. And the opposite should be true if a reader is processing words visually. However, phonological coding can be pre- or postlexical. If this kind of coding is postlexical then one should say that the word is processed first visually, then recoded phonologically to conform with task demands (as in oral reading) or readers' strategic checking.

According to Glushko's (1979, 1981) model of reading by analogy, such postlexical recoding is the only role played by phonological codes. In contrast, Coltheart's (1978) model of word recognition emphasizes the crucial role of prelexical phonological codes in the form of GPC rules. In an attempt to determine the relative accuracy of Glushko's versus Coltheart's views of phonological coding, two forms of a word recognition test were constructed, a form with clues and a form without clues. In the form with clues, a clue word was presented which was consistent either with the beginning of the target (onset) or with the end of the target (rime). The child was asked to find the target from a list of seven alternatives. Alternatives are consistent with initial and/or final letter-sounds of the clue or target. If word recognition is an analogical process, then the specific word association provided by the clue word should facilitate word recognition most for those weak in lexical entries, as indicated by scores on a vocabulary test. Indeed, those replete with lexical entries may find the clue word distracting to the activation of their own associations or to activation of GPC rules.

In sum, our hypothesized answer to today's symposium's question "What's specific about specific reading disability?" is: Nothing, except quantitative differences suggestive of lower placement on the same continuum of visual and phonological coding skills. Thus, one expects to see the regularity effect in good readers in tasks clearly demanding application of GPC rules, such as spelling (e.g., Olson, 1985), or in tasks clearly demanding phonological recoding, such as oral reading (e.g., Frith & Snowling, 1983). But in tasks not so biased toward use of phonological codes, such as recognizing a word from a list of words, one can expect to see good readers' reliance on visual-orthographic codes as well as phonological ones, and poor readers' emerging proficiency in application of phonological recoding.

Method

Subjects

Eighty first graders from three schools in Houston, Texas, representing middle-class populations, participated in the study. Half the subjects attended a public school where reading was taught by the whole word approach, while the other half attended two parochial schools where reading was taught by the phonics approach. Ages ranged from 6.1 to 7.10 with a mean of 6.9. Two subjects in the whole word approach group were repeating first grade.

Materials

Sixty single-syllable, real English words were selected for the reading and spelling measures: 78% had four letters; 17% had 5 letters; and 5% had 3 or 6 letters. Of the 60 words, 40 had regular spelling patterns and 20 had exception spelling patterns. Frequencies were

checked by referring to Carroll, Davis, and Richman (1971) and by pilot-testing the words with 6- and 7-year-olds.

Procedure

Subjects were administered the Gates-McGinitie Reading Test, Basic R, in October. Subjects whose grade equivalency scores were greater than 1.3 were categorized as good readers and those with scores equal to or less than 1.3 were categorized as poor readers. (Because the school year begins in August in these schools, a cut-off of 1.3 seemed appropriate.)

The spelling test consisted of five groups of 12 words each. Each group consisted of 8 randomly selected regular words and 4 randomly selected exception words. Sentences were written for each word. The teachers administered the spelling test over the period of a week, during language arts time, one group of 12 words per day.

After the spelling test was completed, children were individually administered, in two 25-minute sessions, the Peabody Picture Vocabulary Test (PPVT-Form L), an oral reading test of the 60 words, a recognition reading test of the 60 words, and Rosner's (1979) Test of Auditory Analysis Skills (TAAS). Oral reading was assessed by individually presenting, in two random orders, the 60 words printed individually on 3 x 5 cards. Responses were audio-taped.

The recognition test consisted of 60 lists of seven words, either with (clue condition) or without (no clue condition) a clue word typed in bold at the top of each list. (In addition, two preliminary practice lists were administered.) In the no clue condition the experimenter stated the word, pointed to the list of seven words, and asked the

child to mark the number next to the word the experimenter had said. In the clue condition the experimenter pointed to the bold-typed word, pronounced it (pausing for the child to pronounce it too), and then pointed to the list of seven words and asked the child to mark the number next to the target word. Alternatives in each list were consistent with initial and/or final letter-sounds of the clue or target. For example, "This word is **cart**. Which word is 'tart'?" (from the list coal, part, tart, curt, tort, tick, and flirt). Coal, part, curt, and flirt relate to initial and/or final sounds of the clue "cart" (as well as to the target in the case of part, curt, and flirt). Tort, tick, and the correct choice, tart, relate to the initial and/or final sounds of the target. In this example the clue and target are regular words with similar ending sounds (rimes). In other test items clues and targets have the same beginning sounds (onsets). The first 20 items of the recognition test had regular clues and regular targets. In the next 40 items half had regular clues and exception targets and half had exception clues and regular targets. Two random orders of these latter kinds of items were obtained, one in which regular clues and exception targets came first and one in which exception clues and regular targets came first. For both random orders the test began with the 20 items with regular clues and regular targets.

The final test administered was Rosner's (1979) Test of Auditory Analysis Skills (TAAS). This 13-item test requires deletion of initial, medial, and final sounds, first at the syllable level, then at the phoneme level. For example, "Say picnic, now say it again without pic (nic)." Other items are: coat-oat and wrote-row; play-lay; and stale-

sale.

Scoring of reading and spelling measures

Accuracy scores for spelling, oral reading, and recognition reading were derived by computing proportions of correct responses for regular words and for exception words. Spelling and oral reading errors were categorized as phonetic or non-phonetic, in similar fashion to Mitterer's (1982) coding of conservative and liberal. In phonetic errors every letter is given a plausible sound value, even though some may be incorrect. For example, the spellings krom and fas are phonetic errors for the exception words chrome and phase and lim and rat are phonetic misspellings for the regular words lime and rate. No sounds have been omitted and no extraneous sounds have been included. In contrast, kut for putt, cal for shall and bolw for bowl are non-phonetic errors.

Proportions of errors on regular and exception words which were phonetic or nonphonetic were calculated for each subject's oral reading and spelling tests. The relevant dependent variable was the difference between these proportions.

Errors on the word recognition test were categorized as relating to the clue or relating to the target. So in the **cart**-tart example given above, coal, part, curt, and flirt have beginning and/or final sounds similar to the sounds in the clue word, **cart**. The other two alternatives in this example, tort and tick relate to beginning and/or final sounds of the target, tart. The dependent variable was a difference score between proportions of errors on regular and exception words which related to the clue or related to the target. Also obtained

were differential proportions of selecting the two alternatives relating to the target when the target was an exception word. For example, in the item with **home** as the clue and comb as the target, there is an important distinction between the two alternatives related to the target, crib and come. Come is the regularized spelling pattern for comb, as evidenced by the regular clue, home. Selection of the alternative, crib, ignores this regularity effect and, instead, suggests reliance on letter knowledge gained most likely through familiarity with the target's spelling.

Results

Results of analyses of reading and spelling measures will be presented first, followed by results of analyses examining the relationship between the Test of Auditory Analysis Skills (TAAS) and reading and spelling measures.

Analyses of reading and spelling measures

Analyses of reading and spelling measures were conducted as 2 (types of readers) x 2 (kinds of reading instruction) analyses of variance with repeated measures of type of word (i.e., regular and exception words). Analyses of the recognition reading test included an additional between-subjects factor of clue versus no clue condition. The dependent variables for these analyses were proportions of correct responses and differences between mean proportions of non-phonetic and phonetic errors. Alpha levels were split in half accordingly: .05/2=.025. PPVT raw scores were initially considered as a covariate because (1) good readers were significantly better than poor readers on this measure, $F(1,76) = 4.96$, $p < .05$, and (2) correlations between

PPVT and Gates-MacGinitie raw scores were different for the two instructional groups, $r = .41$, $p < .01$ for whole word readers and $r = .04$, $p > .05$ for phonics readers. But when analyses of variance with repeated measures were conducted, tests of regression were insignificant in all instances except the analysis of spelling errors. Since PPVT scores were clearly contributing little to the analyses, they were dropped as a covariate.

Mean proportions correct and differences between mean proportions of non-phonetic and phonetic errors for reading and spelling tests are presented in Table 1.

Insert Table about here

In the analysis of proportion of correct responses on the oral reading test, there were significant main effects of reader, $F(1,76) = 32.78$, $p < .001$ and type of word, $F(1,76) = 49.15$, $p \leq .001$. There was also a significant reader x type interaction, $F(1,76) = 26.30$, $p < .001$. By looking at the means of Table 1 we see that good readers were almost twice as accurate on regular words as they were on exception words. In contrast, poor readers' low accuracy favored regular words only slightly.

In the analysis of errors in oral reading, there was a significant main effect of reader, $F(1,76) = 9.12$, $p < .01$, with poor readers having greater positive differences between proportions of non-phonetic and phonetic errors than good readers. Although the interaction of reader x type was not significant at $p < .025$ [$F(1,76) = 3.98$, $p =$

.05], we see from the means of Table 1 a tendency for poor readers to make non-phonetic errors on exception words more than on regular words, while for good readers there was little difference in performance for either type of word.

Similar patterns of significant main effects and interactions were obtained for spelling accuracy and for spelling errors: Reader, $F(1,76) = 34.58$ and 14.15, $p < .001$; Type, $F(1,76) = 96.02$ and 14.14, $p < .001$; and Reader x Type, $F(1,76) = 40.21$, $p < .001$ and 8.83, $p < .01$. We see from the means in Table 1 that good readers were seven times more accurate in their spellings of regular words than exception words. A similar tendency was apparent from poor readers, but their scores on exception words suffered from a floor effect. With respect to the difference between proportions of non-phonetic minus phonetic errors, poor readers' means for exception and regular words are essentially zero. Thus, poor readers' spelling errors were equally likely to be phonetic or non-phonetic. Good readers, on the other hand, tended to spell phonetically (as indicated by the negative difference) and did so almost twice as often on exception words as on regular words. In other words, good readers over-regularized their spellings of exception words.

In the analysis of accuracy rates on the recognition test there were significant main effects of reader [$F(1,72) = 29.58$, $p < .001$], favoring good readers, type of word [$F(1,72) = 248.92$, $p < .001$], clue condition [$F(1,72) = 9.00$, $p < .01$], and type of word x clue condition [$F(1,72) = 5.99$, $p < .025$]. Examination of means in Table 1 reveals that the difference between clue and no clue conditions was significant

for regular but not for exception words. Accuracy was better for the no clue condition.

Analysis of errors on the recognition test compared differences between proportions of target-related errors and proportions of clue-related errors for regular and exception words. There was a significant main effect of reader, $F(1,72) = 10.42$, $p < .01$ and significant interaction of reader x clue condition, $F(1,72) = 5.36$, $p < .025$. Notice in the last row of Table 1 that the difference between good and poor readers is most obvious in the no clue condition. Interestingly, poor readers selected more target-related alternatives in the clue condition, while good readers did so in the no clue condition.

Finally, an analysis was conducted on exception words to distinguish performance on the two target-related alternatives in the recognition test. There was a significant main effect of type of alternative, $F(1,72) = 232.04$, $p < .001$ and significant reader x type of alternative interaction, $F(1,72) = 14.41$, $p < .001$. In one alternative the initial and final letters were the same as the target (medial sound error) and in the other the spelling pattern was the same as the clue (over-regularization error). Good readers' mean proportions for the medial sound error and the over-regularization error were .13 and .68, respectively. Poor readers'corresponding mean proportions were .22 and .53. In other words, when good readers erred on recognizing exception words, they were more likely to over-regularize than to err on medial sounds. This tendency was not nearly as apparent in poor readers.

Relationship between auditory scores and reading and spelling scores.

Good readers scored significantly higher on the Test of Auditory Analysis Skills (TAAS) than poor readers, $F(1,76) = 11.95$, $p < .01$. The poor readers' mean of 5.36 and the good readers' mean of 8.35 suggest different levels of phonemic segmentation ability. The fifth item is "Say meat, now say it again without /m/ (the "m" sound)." The eighth item is "Say wrote, now say it again without /t/." Thus, on the average, poor readers were able to segment and delete initial sounds while good readers were able to segment and delete final sounds as well.

Correlations between TAAS scores and reading and spelling scores are presented in Table 2.

Insert Table 2 about here

The most striking point about the pattern of correlations in Table 2 is that there are no significant correlations between TAAS and reading and spelling measures for poor readers. However, for good readers there are significant, moderate correlations between TAAS and oral reading measures and one spelling measure. Furthermore, the TAAS-oral reading correlations are positive for proportions of regular and exception words correct ($r = .51$ and $.44$, $p < .001$) and negative for the proportions of non-phonetic minus phonetic errors in regular and exception words ($r = -.50$ and $-.44$, $p < .001$). In other words, as good readers' auditory deletion scores improved, the proportion of oral reading errors that were phonetic increased (and the proportion of non-phonetic errors decreased, resulting in negative difference scores).

Finally, the spelling measure that correlates significantly with good readers' TAAS scores is the proportion of regular words spelled correctly, $r = .49$, $p < .001$.

Discussion

This investigation focused on how good and poor readers in the first grade process words. Specifically, to what extent do beginning readers process real English words phonologically, visually, or both? And to what extent does the processing differ for those above grade-level in reading achievement compared to those below? Results reported in this paper are based on beginning-of-the-year data collection -- October of the first grade year. Mid-year data collected in February are currently being analyzed and end-of-the-year data will be collected in May. The picture we wish to paint is preliminary and the good and poor reader profiles we see are clearly emergent, awaiting the possibly differing effects of whole word or phonics instruction during the school year. Consequently, we were not surprised at the lack of significant effect of method of reading instruction on reading and spelling scores. Instead, our focus was on the patterns of performance on regular and exception words exhibited by good and poor readers. In short, would there be significant reader by type of word interactions, with good readers but not poor readers exhibiting a regularity effect indicative of phonological coding? Or would there be no qualitative difference in the way good and poor readers process words and, hence, no significant reader by type of word interaction?

The answers to these questions, based on the present data, are Yes, good readers but not poor exhibit a regularity effect in analyses

of proportions of regular and exception words read aloud correctly and spelled correctly and in analyses of spelling errors and exception word errors in recognition reading. And, importantly, these were the measures revealing significant correlations with phonemic segmentation ability. To summarize the regularity effect, good readers' accuracy on regular words compared to exception words was twice as great in oral reading and seven times as great in spelling. And good readers' tendency to produce phonetic spelling errors was particularly apparent when the word was an exception word, a phenomenon known as over-regularization. Over-regularization was also more characteristic of good readers than of poor readers when selecting exception word targets on the recognition test. Good readers were five times more likely and poor readers twice as likely to select an alternative representing the regularized pattern, such as come for comb, than the alternative representing identical first and last letters, such as crib. This tendency to over-regularize exception words occurred regardless of clue condition.

In spite of some strong evidence that good readers sometimes processed words phonologically, there was also evidence that they sometimes did not and that poor readers were not necessarily deficient in phonological coding. First, consider the analyses in which good readers did not demonstrate a regularity effect: analysis of errors in oral reading; analysis of accuracy in recognition reading; and analysis of errors in recognition reading. All readers' errors in reading regular and exception words aloud reflected greater proportions of non-phonetic errors compared to phonetic errors. Non-phonetic errors

reflect implausible letter-sound connections. The fact that good and poor readers did not differ significantly ($p > .025$) in their pattern of performance on regular compared to exception words and that the errors they produced were phonetically implausible, challenges the conclusion that good and poor readers differ qualitatively in their word processing. The regularity effect that showed up when good readers read words aloud correctly may reflect skilled postlexical phonological coding to meet the requirement of oral output. But good readers' tendency to use prelexical phonological coding appears limited, except when asked to spell these words.

Finally, the nature of good and poor readers' errors in the recognition test varied depending on whether a clue was present or absent. Poor readers were more likely to select alternatives related to the target under the clue condition than under the no clue condition. Just the opposite was true for good readers. Perhaps poor readers are able to compensate for lack of lexical entries (as indicated by PPVT scores) by using a clue word to read, by analogy, a target. Such a process involves processing visual-orthographic patterns in clue words and optional postlexical phonological recoding (see Glushko, 1979, 1981). For the good reader, however, the clue word is less facilitative than not having a clue at all. Perhaps access to their greater store of lexical entries was uninhibited for good readers in the no clue condition but inhibited in the clue condition. Such reading-by-analogy interpretations of good and poor readers' word processing are plausible for regular words. But what about good readers' greater tendency to exhibit more errors in over-regularization than in medial sounds when

recognizing exception words? Because this tendency occurs regardless of clue condition, we conclude that good readers more than poor applied (pre-lexical) GPC rules, in accord with Coltheart's (1978) model of reading.

In conclusion, both good and poor readers processed words differently depending on the nature of the task. Good readers clearly shone in phonological recoding and application of GPC rules and were weaker in utilization of visual-orthographic knowledge. Poor readers demonstrated a preponderance of visual over phonological coding and the ability to benefit from visual-orthographic knowledge available in a clue. As we analyze mid-year and end-of-the-year data, we will note the changing profiles of good and poor readers and the possible moderating effects of reading instruction. And we wait to see if a subset of poor readers emerges that resists the move up the continuum of skills to a mixture of phonological recoding and visual-orthographic analysis. We will greet such a group not only with training in phonological recoding but with training in visual-orthographic patterns based on Treiman's (1985) notion of onset and rime. A matched control group will receive the usual phonics remediation of phonemic segmentation and blending. By comparing the progress of these two groups we will be in a much better position to judge whether it is a phonological deficit per se that accounts for individual differences in readers (see Stanovich, 1986).

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Table 1

Mean proportions correct and differences between mean proportions of non-phonetic and phonetic errors for reading and spelling tests

	Good Readers		Poor Readers	
	Regular	Exception	Regular	Exception
Dependent variable				
Oral Reading				
% correct	.42	.22	.12	.09
Diff. in errors	.21	.20	.41	.54
Spelling				
% correct	.22	.03	.05	.01
Diff. in errors	-.23	-.41	.01	-.02

	Clue Condition		No Clue Condition	
	Regular	Exception	Regular	Exception
Recognition Reading				
% correct	.56	.29	.72	.35

	Readers		Readers	
	Good (n=24)	Poor (n=15)	Good (n=28)	Poor (n=13)
Diff. in errors	.62	.58	.70	.44

Table 2

Correlations between Test of Auditory Analysis Skills (TASS) scores and reading and spelling scores for good and poor readers

	Test of Auditory Analysis Skills	
Dependent Variable	Good Reader (n=52)	Poor Reader (n=28)
~~Oral Reading~~		
% Correct		
Regular words	.51**	.15
Exception words	.44**	-.08
Diff. in error types		
Regular words	-.50**	.19
Exception words	-.44**	.18
Spelling		
% Correct		
Regular words	.49**	.19
Exception words	.27	.13
Diff. in error types		
Regular words	-.22	.10
Exception words	-.21	.00
Recognition reading		
% Correct		
Regular words	.32	.10
Exception words	.35*	.21
Diff. in error types		
Regular words	.20	.04
Exception words	.22	-.07

Note. - ** $p < .001$; * $p < .01$